Role of lithotrophic Fe-oxidizing bacteria in iron cycling in shallow marine sediments

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Iron redox cycling in marine sediments is an important avenue for the supply of dissolved iron to the ocean. While the overall biogeochemistry of this process is understood, the role played by specific microbes is less well appreciated. We investigated the distribution of O_2-dependent Fe-oxidizing bacteria (FeOB) in intertidal sediments of Maine, and used these data to extrapolate their potential role in coastal sediments on a global scale.

Specifically we investigated the iron-encrusted burrows of marine worms. Zetaproteobacteria, a class of marine FeOB, were abundant at worm burrow walls (median = 1.1 %; range = 0.04-15 %) compared to bulk sediment (median = 0%; range = 0-1%;). The abundance of Zetaproteobacteria decreased with depth in bioturbated sediments, and was positively correlated with pore water Fe(II) concentration. Enrichments for lithotrophic FeOB from burrow walls yielded three new phylotypes of Zetaproteobacteria. Strain CSS1 represented ZetaOtu14, the most abundant Zetaproteobacteria OTU found in burrow walls, while the other two strains (SR-1 and Echo-1) represented minor OTUs. All three strains were obligate Fe-oxidizers. Based on these local findings, we conducted a meta-survey of datasets from 16S rRNA gene analyses of global coastal sediments and found similar abundances and distribution patterns of Zetaproteobacteria. From this we estimated a Zetaproteobacterial global total of 10^{26} cells in coastal, bioturbated sediments (10 cm depth, <150 m water depth). This could equate to an annual production of approximately $7.9 \cdot 10^{15}$ grams of sedimentary iron oxides—twenty-five larger than the annual flux of iron oxides by rivers ($3 \cdot 10^{14}$ grams) to coastal sediments. These data suggest that iron-oxidizing Zetaproteobacteria are abundant and active in marine sedimentary environments, and are an important biological control on the sedimentary iron cycle, linking reduced and oxidized phases of iron. Ecologically, we hypothesize that Zetaproteobacteria may function as keystone organisms in marine sediments by dint of their relatively low numerical abundance, yet capacity to exert a large affect on sedimentary biogeochemistry by the production of biogenic iron oxides.